

GAO

Report to the Chairman,  
Subcommittee on Defense,  
Committee on Appropriations,  
House of Representatives

September 1999

# DEFENSE ACQUISITIONS

## Challenges Associated With Implementing the Joint Tactical Radio System



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United States General Accounting Office  
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National Security and  
International Affairs Division

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The Honorable Jerry Lewis  
Chairman, Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

Dear Mr. Chairman:

The Department of Defense (DOD) is consolidating various service-unique radio acquisition programs into the Joint Tactical Radio System (JTRS). Through this consolidation, DOD expects to acquire JTRS units to replace all of its current radio inventory, avionics upgrades, appropriate satellite terminals, and personal communications systems. Although total program costs have yet to be determined, DOD officials estimate it could cost billions to replace about 200 types of radios, with a replacement potential of over 750,000 existing units—also known as legacy systems. The JTRS program's key objectives are to achieve cost savings, improve performance, and provide an interoperable communications system that enables joint and coalition forces to work together.

The former Subcommittee Chairman requested that we evaluate the JTRS acquisition strategy and management plans. As agreed with his office, we (1) determined the status of the JTRS program, including DOD development plans and (2) identified challenges program officials will face in implementing the JTRS acquisition strategy.

## Results in Brief

The JTRS program is in a start-up stage. DOD has directed the services to stop development of new radio-based programs but has granted a limited number of waivers to meet near-term requirements because JTRS products<sup>1</sup> are not yet available. DOD is currently developing a JTRS

<sup>1</sup>JTRS products are a combination of hardware and software developed from and compatible with the JTRS architecture.

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architecture<sup>2</sup> and detailed refinements to its preliminary acquisition strategy. DOD is scheduled to reach a major decision point in October 2000, when it is expected to approve the architecture and major revisions to the current acquisition strategy. The revised acquisition strategy is expected to define JTRS products, provide cost estimates for them, and allow development of an estimated total program cost. Following this, the services are expected to finalize their plans to replace existing radios with JTRS products. DOD then expects the services to begin procuring JTRS products with JTRS Joint Program Office support.

DOD must successfully address three key challenges to achieve its program objectives. These challenges are (1) completing a plan to develop key technologies not available from commercial sources or other DOD radio programs and integrating these new technologies into JTRS products; (2) defining an architecture that will be acceptable to commercial industry, be valid across a wide range of operating scenarios, and be useful to the services in developing plans to replace existing radio systems; and (3) defining interoperability requirements and establishing a strategy to procure and test products that meet these requirements.

We are recommending that DOD focus on establishing the scope of JTRS interoperability requirements and developing a more structured technical and architecture development process.

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## Background

The primary impetus for the JTRS program came from congressional and DOD concerns about the inability of service radios to adequately work with one another and the cost of buying and maintaining these radios. The Secretary of Defense Planning Guidance for fiscal years 1999-2003 directed the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (C3I), in coordination with the Chairman of the Joint Chiefs of Staff and the services, to define DOD-wide requirements for digital, modular, software-programmable radios. This guidance also directed the Assistant Secretary to establish a joint program for a family of radios that would consolidate similar programs under

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<sup>2</sup>DOD defines an architecture as "a framework or structure that portrays relationships among all the elements of the subject force, system, or activity." The JTRS Joint Program Office describes its proposed JTRS architecture as a technical architecture that would define (1) the functional entities and their interrelationships, (2) the physical implementation of the JTRS architecture, and (3) the framework for waveform/application developers. A waveform is a plot of an electrical quantity's amplitude versus time.

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development by the services such as the Army's Near-Term Digital Radio (NTDR), the Navy's Digital Modular Radio (DMR), and the Air Force's Airborne Integrated Terminal Group (AITG).

In response to this directive, DOD officially established the JTRS program in September 1997.<sup>3</sup> In December 1997, the Under Secretary of Defense for Acquisition and Technology (A&T) appointed the Army as the program's lead service and acquisition executive and directed that a joint program office be established to manage the development of an evolutionary architecture and perform management functions. The Army established a special task force for the JTRS program until the Joint Program Office was established in October 1998.

The program's objectives, established by DOD, focus on providing a family of digital, modular, software-programmable radios that would allow military commanders to communicate with their forces through voice, video, or data formats as needed. Radios would range in configuration from a low-cost joint tactical radio to a higher capability, joint multiband, multimode radio. This approach accommodates the services' many individual requirements, including space and size, and the many different configurations—airborne, ground mobile, fixed station, maritime, and personal communications—in which the radios will be used. DOD's underlying concept is that the radios could be programmed or configured to function in a number of modes and frequencies to fit a user's specific needs. By combining functions and using common components, DOD believes the services will be able to reduce unit costs and the number of radios needed.

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## Current Status of the JTRS Program

The JTRS program is in a start-up stage. DOD approved a JTRS Joint Operational Requirements Document in March 1998. Although DOD has directed the services to stop development of new radio-based programs other than JTRS, it has granted waivers allowing the services to buy non-JTRS products to meet near-term requirements because JTRS products are not yet available. DOD is also developing a JTRS architecture and a detailed acquisition strategy that is expected to lead to a major program decision point in October 2000.

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<sup>3</sup>The program was originally named the Programmable Modular Communications System. It was renamed in December 1997.

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## Restrictions and Waivers on Acquiring Non-JTRS Radios

The JTRS program consolidates radio development programs that were separately funded and directed by individual services. As acquisition executive, the Army has programmed \$344 million in research and development funds for the JTRS program through fiscal year 2005. Joint Program Office officials said these funds will support development and validation of the JTRS architecture, provision of standard waveforms,<sup>4</sup> establishment of a certification facility to validate that products comply with the approved architecture, and funding for technology insertion.

In an April 10, 1998, memorandum, the Under Secretary of Defense (A&T) expressed concern about the services continuing with near-term radio and terminal development programs outside the JTRS program. He believed these efforts could waste resources by continuing the fielding of legacy systems and delay the earliest possible fielding of JTRS equipment. The Under Secretary of Defense (A&T) requested each service acquisition executive to minimize development of new programs. On August 28, 1998, the Assistant Secretary of Defense for C3I also expressed concern about continuing efforts to independently develop and acquire service-unique radios and terminals. He directed the services to suspend all efforts to develop and acquire any radio systems, including those with software programmable radio technology.

Congress has also voiced concern that the services are continuing to develop duplicative radio programs. The House Appropriations Committee Report on DOD Appropriations for 1999 directed that no more than 25 percent of funds appropriated for research and development of a tactical radio be obligated until the Assistant Secretary of Defense for C3I certifies in a report to Congressional Defense Committees that the development program (1) meets interoperability requirements, (2) does not duplicate other development efforts, and (3) is fully funded.<sup>5</sup> According to an official from the office of the Assistant Secretary of Defense for C3I, this report was being processed in August 1999.

No JTRS products have been fielded to date, and no date for such fielding has been scheduled. To meet near-term requirements in the absence of JTRS products, DOD has granted a limited number of waivers to the

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<sup>4</sup>A waveform can include system-unique data on anti-jam characteristics, error control information, and timing information.

<sup>5</sup>House Appropriations Report 105-591, DOD Appropriations Bill, 1999, p. 177.

services to continue radio programs that meet immediate needs. As of June 1999, the Assistant Secretary of Defense for C3I had granted nine waivers. DOD documentation shows that the first three waivers addressed immediate service communication needs.

- The Army received permission to buy 174 NTDR units for its digitization program because it claimed the radios did not duplicate any other DOD program, provided a bridge to JTRS, met interoperability requirements, and were fully funded. The Army told us the radios would be used to meet current battlefield digitization requirements in the First Digitized Division; however, it has not requested funds to buy more of these radios for the First Digitized Corps.
- The Navy was allowed to buy DMR's to meet fielding requirements for its radio replacement program through fiscal year 1999 because JTRS products were not available to meet these requirements and these radios were not considered a competitor to JTRS.
- The Air Force received permission to buy AITG units (an ultrahigh frequency terminal) to meet communications and air safety requirements because JTRS products were not available.

The JTRS Program Manager said the other six waivers were to meet near-term requirements. These requirements include providing the services with "beyond line of sight" radio capabilities and reducing the number of radios required for special operations and close air support. He said that all waivers are temporary and that the services are required to resubmit requests before further procurement of these radios.

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#### Development of JTRS Architecture and Acquisition Strategy

DOD is developing the JTRS in three phases. In phase one, the Joint Program Office awarded contracts to three consortia<sup>6</sup> to define to what level and how the JTRS architecture should be developed. In phase one, which ended in June 1999, the Joint Program Office reviewed products from the three consortia. In phase two, the Joint Program Office plans to conduct a competition for a single award to develop the architecture and demonstrate it in a laboratory environment. In addition, the Joint Program Office plans to conduct a market survey in this phase to determine industry readiness to produce JTRS compliant systems. The Assistant Secretary of Defense for C3I's Major Defense Acquisition Program Overarching

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<sup>6</sup>The three consortia are teams of multiple contractors and universities. Motorola, Boeing, and Raytheon lead one team each.

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Integrated Product Team<sup>7</sup> will then review the JTRS program. The team is expected to recommend an acquisition strategy to the Under Secretary of Defense (A&T).

At the October 2000 program decision point, the Under Secretary of Defense (A&T) is expected to provide guidance on the JTRS acquisition strategy and implementation. At that time, the Under Secretary of Defense (A&T) will

- review the JTRS architecture developed and validated by the JTRS Joint Program Office,
- analyze the results of the market survey of commercially available products and technology and the recommendations of the Overarching Integrated Product Team, and
- decide whether commercial technology is adequate for JTRS to proceed directly into production or whether additional research and development is required.

DOD and Joint Program Office officials anticipate that the decisions reached at the October 2000 major program decision point will provide the Army and the other services with an approved JTRS architecture that enables them to proceed immediately into production. DOD anticipates that this architecture will define JTRS products, enable preparation of product and total program cost estimates, and provide the services with sufficiently developed hardware and software prototypes that they can use to immediately procure JTRS products.

The third phase will begin after the Under Secretary of Defense (A&T) has chosen a detailed acquisition strategy. This phase will consist primarily of service procurement actions in accordance with their implementation plans to replace legacy radio programs with JTRS products. DOD expects the commercial marketplace to provide competitively priced products that meet DOD requirements and are built to the JTRS architecture because the

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<sup>7</sup>The team provides assistance, oversight, and reviews as a program proceeds through its acquisition life cycle and resolve issues at the lowest level possible. The team comprises the program manager, the program executive officer, component staff, joint staff, Under Secretary of Defense (A&T) staff, and Office of the Secretary of Defense staff principals or their representatives assigned to a specific program.

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architecture will be based on open system standards.<sup>8</sup> During phase three, the Joint Program Office is also expected to acquire JTRS architecture-compliant waveforms for service use, upgrade the architecture to keep it current with technology advances, and develop JTRS certification facilities.<sup>9</sup>

Congress has expressed concern that key decisions on the architecture, acquisition strategy, and interoperability should be accelerated. The House Appropriations Committee Report on DOD Appropriations for 2000 directed DOD to provide a report to the Committee on its strategy for developing and fielding the JTRS by December 15, 1999. The plan is to address priority radios for replacement, cost of the development program, a development schedule, and estimated unit cost of production radios.<sup>10</sup>

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## JTRS Program Faces Three Key Challenges

DOD faces three key challenges to successful realization of JTRS program objectives. First, despite DOD's expectations of success, recent studies indicate that current commercial technology may not be available to fully support the replacement of existing service radios with JTRS products and may not support future JTRS requirements. Second, a single architecture that can become the commercial standard for software programmable radios will be difficult to achieve. Third, the JTRS Operational Requirements Document, although developed with input from warfighters, does not fully define interoperability goals for joint and coalition warfare operations.

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### Commercial Technology Development May Not Fully Meet JTRS Requirements

DOD's acquisition strategy and fielding plans for JTRS rely heavily on current commercial technology for initial fielding of JTRS products and rapid advancement of commercial technology to meet future JTRS requirements. DOD intends to leverage commercial technology as well as

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<sup>8</sup>Open system standards are widely accepted and supported standards set by recognized standards organizations, or the commercial marketplace. These standards support interoperability, portability, and scalability and are equally available to the general public at no cost or with a moderate license fee. An open system implements sufficient open standards for interfaces, services, and supporting formats to enable properly engineered components to be used across a wide range of systems with minimal changes, to interoperate with other components on local and remote systems, and to interact with users in a style that facilitates portability.

<sup>9</sup>As of June 1999, the Joint Program Office had not defined what these certification facilities would do.

<sup>10</sup>House Appropriations Report 106-244, DOD Appropriations Bill, 2000, pp. 214-215.

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technology being developed by the Defense Advanced Research Projects Agency (DARPA) to support rapid technology insertion into the JTRS program. However, DOD may have difficulty in acquiring commercial technology to meet key JTRS requirements. In addition, it does not have a formal plan to develop technologies not available from commercial sources, integrate these technologies into JTRS products, and coordinate related DOD and service research programs with JTRS development plans.

Our analysis of recent reports by the RAND Corporation and the National Research Council, our discussions with DOD laboratory and program officials, and service reports all show that the private sector is unlikely to meet all key JTRS military performance requirements and that DOD must have a well-defined development program to meet these unmet needs (see app. I). The private sector does not need all of the features included in military requirements and is unlikely to develop needed technologies without an established market. The private sector, for example, relies upon a fixed infrastructure for mobile communications, while the military must be able to operate without fixed infrastructure. The mobile infrastructure is a key requirement to Army development initiatives. A companion report said military and commercial users of wireless communications systems have very different requirements, including those for waveforms and signal processing.<sup>11</sup>

According to the Joint Program Office, industry has also identified key technologies that are not required by commercial users. A November 1998 Joint Program Office assessment of industry responses to its survey showed that military technology hardware and software requirements exceed commercial requirements, including those for antennas, information security techniques, power amplifiers, and network management. In their responses to the first architecture definition contracts, industry officials also identified significant hardware and software technology issues that must be addressed by the JTRS program.

Ongoing DOD and service research programs are developing technologies of potential use to the JTRS program that the private sector is not expected to develop and market in the near future. For example, DARPA began a comprehensive program in 1994 called the Global Mobile Information Systems, which focused on developing wireless network protocols, "smart"

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<sup>11</sup>Emerging Commercial Mobile Wireless Technology and Standards: Suitable for the Army?, the RAND Corporation (MR-960-A, 1998).

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antennas, and other radio technologies. Another DARPA technology program, called ULTRA COMM, is intended to reduce the logistical costs and size of next-generation communications systems and add operational flexibility. A third DARPA program, the Advanced Digital Receiver Technology program, was initiated to demonstrate technologies for software-defined radios. Finally, a fourth DARPA program, called the Battlefield Awareness and Data Dissemination Advanced Concept Technology Demonstration, includes other radio and communications technology such as the Global Broadcast Service. This system is a space-based high data rate communication link providing information from the United States or other rear-echelon locations to military forces deployed in the field.

The services have also been allowed to continue software programmable radio research projects that could provide useful information to the JTRS program. For example:

- The Army is continuing development of the NTDR, which can identify network management problems and potential solutions. The Army is also establishing a wideband network radio project that can evaluate network protocols and software radios to deliver the high data rates that the Army has said it requires.
- In addition to its DMR program, the Navy has a High Data Rate Line of Sight waveform development project that is software programmable to improve battlegroup communications.
- The Air Force is currently leading development of a smart network radio as part of DOD's Defense Technology Objectives.

However, leveraging this experience may be difficult. DOD and service research programs are not adequately coordinated with JTRS development plans, reducing opportunities for the program to directly address technology needs not satisfied by the commercial marketplace. The Joint Program Office has begun initial studies of commercial and DOD-sponsored technologies. However, no formal process or technology development plan exists to monitor current commercial and DOD technology development efforts or to identify unmet technological requirements that will have to be met to satisfy all JTRS requirements. Such a plan is expected to be available in the near future, according to DOD. In commenting on our draft report, DOD stated that the Joint Program Office is preparing a JTRS Technology Master Plan and that this plan will provide a framework for focusing technology efforts such as those underway Department-wide.

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The Joint Program Office has also acknowledged the need for a closer working relationship with DARPA. Joint Program Office officials said their staff have limited, informal contacts with individual DARPA program managers and service technical staff because no formal mechanism is available to ensure the transition of relevant technology from DARPA to the Joint Program Office or the services. Joint Program Office officials told us they are in the process of approaching DARPA to establish a written agreement.

In addition, DOD does not have a process to manage the development of new technologies to meet JTRS requirements, integrate existing technologies to meet JTRS requirements, or ensure that technologies are mature before introduction into JTRS. In our work on best practices in managing advanced technology development, we found that maturing new technology before including it in products is one of the main determinants of success in commercial product development.<sup>12</sup> This practice holds promise for DOD because immature technologies have been a main source of problems in developing weapon systems. However, budgetary, organizational, and other factors within DOD make it difficult to bring technologies to high readiness levels before including them in weapon systems. These factors encourage science and technology organizations such as DARPA to disengage from technology development too soon and weapon system managers to accept immature technologies. In technical comments to a draft of this report, DOD said that it is beginning to address these issues. According to DOD, the Technology Master Plan will provide a necessary first step toward establishing a clearly defined technology development and/or management plan.

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#### A Single Architecture Will Be Difficult to Achieve

DOD expects to approve a single architecture for the JTRS program at the October 2000 major program decision point. It also expects industry to adopt the architecture for widespread use in the commercial market because the architecture will be developed by industry under DOD contract. DOD's strategy is based on the assumption that a single architecture for software programmable radios based on open commercial standards is possible and will result in a commercial market from which the services could procure JTRS products. On the basis of our analysis of recent reports and studies, we believe that a single architecture based on

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<sup>12</sup>[Best Practices: Managing Advanced Technology Development Can Improve Weapon System Outcomes](#) (GAO/NSIAD-99-162, July 1999).

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open commercial standards may not be universally adopted by industry and may not be technically possible, at least in the near term.

A 1997 National Research Council study, sponsored by DARPA, discussed the difficulties in achieving widespread consensus on standards in wireless communications. The study concluded: "For a worldwide operator, the management and coordination of diverse systems are complicated by the absence of any trend toward convergence toward a single standard in wireless communications."<sup>13</sup>

According to the report, Europe, Japan, and the United States have different wireless technologies, and although new commercial technology may be developed, the commercial deployment of that technology is not ensured. Another National Research Council report said that in coalition warfare, U.S. partners would not necessarily adopt the same set of standards—even commercial ones—as those used by the United States.<sup>14</sup> While commercial firms promise significant progress in software programmable radios within the next several years, standards and architectures in the private sector are now in a state of flux.

DOD's assumption that one architecture can meet all its requirements also may not be technically valid. Industry representatives cited the widely different size and power requirements of DOD's radios, which range from small handheld units to base station radios, as "the single major roadblock" to development of a single architecture. For example, some processing could require more power than is practical for a handheld radio. Responding to industry representatives, a Joint Program Office official said that JTRS provides the focus and impetus necessary to converge on one architecture that covers the full range of requirements.

In January 1999, a Defense Science Board Task Force on Tactical Battlefield Communications made several recommendations designed to aggressively accelerate acquisition of JTRS products. The Board recommended that DOD instruct the Joint Program Office to stop its ongoing architecture development program and contract immediately for

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<sup>13</sup>The Evolution of Untethered Communications, National Research Council (1997).

<sup>14</sup>Realizing the Potential of C4I: Fundamental Challenges, National Research Council (1999).

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development of multiple prototypes using architecture products already developed by the Software Defined Radio Forum.<sup>15</sup> The Board expected the prototypes to be available 12 to 14 months after contract award. In its technical comments, DOD said the Board's recommendation was rejected because it would have resulted in multiple, incompatible prototypes and would not have resulted in open systems. According to Joint Program Office officials, development of a single architecture that will result in compatible, open system prototypes is necessary. However, the Joint Program Office is not funding development of alternative architectures, should a single architecture prove unrealizable. Joint Program Office officials said they still expect to develop a single architecture that is flexible enough to allow multiple implementation configurations.

Also, in its technical comments, DOD said that developing an alternative architecture or making plans for an alternative would serve no other purpose than to encourage the supporters of legacy and non-interoperable systems. DOD also believes that developing an alternative architecture would totally undermine the current cooperation between government and industry and among industry participants. We disagree. First, as discussed above, a single architecture may not be universally adopted by industry and may not be technically feasible. We believe DOD could minimize risks by periodically assessing progress and preparing alternatives to meet identified risks. Second, if industry cooperation is as tenuous as DOD believes, the assumption that industry will accept the JTRS architecture as a standard is unrealistic.

Once approved, the Joint Program Office expects the JTRS architecture to provide a foundation on which the services can finalize implementation plans for replacing or supplementing existing radios with JTRS products. Joint Program Office officials told us they expect the approved JTRS architecture to define the products that will be available and their capabilities. In April 1998, the Under Secretary of Defense (A&T) requested that each service acquisition executive limit development of new programs and transition existing development programs for radio-based communications systems to a target single acquisition program. The JTRS Management Execution Plan states that one of the Joint Program Office's

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<sup>15</sup>The Forum is a nonprofit corporation dedicated to supporting the development, deployment, and use of open architectures for advanced wireless systems.

most important responsibilities is developing and monitoring JTRS plans to replace or supplement existing radios with JTRS products.<sup>16</sup> The Joint Program Office intends to incorporate service-prepared implementation plans into one DOD-wide plan that is based upon a single approved JTRS architecture.

However, establishing effective implementation plans requires clear decisions on the scope of the JTRS program and cost-effective JTRS products. The services contend that effective implementation plans cannot be developed in detail without a clear determination of which systems will be affected by JTRS. DOD concurs with the services. In technical comments on a draft of this report, DOD said the difficulty facing the services, as they migrate to JTRS, is the uncertainty of knowing exactly when a desired capability will be available for incorporation into JTRS, as well as the costs to integrate JTRS-compliant systems into host platforms.

Furthermore, implementing a JTRS architecture, however sound and complete, will take considerable time because fiscal limitations are likely to limit the number and capabilities of JTRS products that can be bought in any single year. Thus, DOD's goal of replacing its entire estimated inventory of 750,000 radios with JTRS products will likely take many years. For example, the Army, as of calendar year 1998, had estimated procurement of about 270,000 Single Channel Ground and Airborne Radio System (SINCGARS) radios, which have an expected lifetime of 20 years. Each of the services has stated that it would have to replace its legacy systems over time because of funding limitations. In its technical comments on a draft of this report, DOD also questioned the adequacy of existing funding for the JTRS program in the services. DOD said that while the services have planned for radio system procurements, they have assumed, in many cases, that they will be procuring "more of the same." As a result, DOD said, there may be inadequate funding to cover the up-front engineering and testing necessary to integrate a new, JTRS-compliant radio system into a host platform.

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#### Interoperability Goals Are Not Fully Defined

The JTRS Operational Requirements Document states that joint, combined, and coalition operations require interoperable command, control, communications, computers, and intelligence capabilities and that JTRS

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<sup>16</sup>The plan provides key details for operating the JTRS Joint Program Office and outlines individual service roles, relationships, and functions in the JTRS program.

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will provide radios to meet these needs. The Operational Requirements Document, which was developed with commanders in chief input, generally defines these requirements. DOD has begun an effort to further define interoperability requirements; however, at the time of our review, these requirements were not fully defined. In addition, the JTRS acquisition strategy does not adequately provide for procurement and testing of JTRS products in joint and coalition operations.

DOD plans to address the interoperability issue by providing the services with standard JTRS waveforms that they can use in their JTRS hardware. According to DOD's technical comments, the JTRS Operational Requirements Document defines the required waveforms, "need by" dates, and intended operating environments. However, DOD has not finalized the selection and prioritization of the waveforms and the many different variations needed to ensure interoperability. The Joint Program Office intends to use an initial set of waveforms (specified in the Operational Requirements Document) until the major program decision point in October 2000, when it intends to deliver waveforms according to commanders in chief priorities and the availability of commercial technology to support those priorities.

The JTRS Program Director said many complex questions must be answered before deciding which waveform modes to use in which JTRS radios. He said that JTRS radios must be compatible with existing radios, but this requirement has not been fully defined. He asked the joint staff for guidance on this issue, and in response, the joint staff sent a message to the commanders in chief and the services requesting they identify their detailed requirements. According to the joint staff message, a consolidated list of requirements is to be delivered for review by the Overall Integrated Product Team no later than August 30, 1999.

Problems in achieving interoperability goals may also be expected because each of the services places higher priority on meeting its own rather than joint requirements. DOD management plans allow the services to control JTRS acquisition, testing, and fielding plans. The JTRS Management Execution Plan only allows the JTRS Program Manager to coordinate various service production programs to meet the operational requirements of each service. The plan also allows the Joint Program Office to use joint service research, development, testing, and evaluation funding only "in a manner that is most responsive to service/mission needs." According to the plan, members of each service assigned to the Joint Program Office also

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represent their respective service and articulate service technical and operational requirements.

In commenting on a draft of this report, DOD agreed with our concerns about defining communications interoperability. DOD said it fully appreciates the requirement for the JTRS to be interoperable within the joint environment and fully supports the need for interoperability. According to DOD technical comments, the Joint Program Office will be the gatekeeper through which no service procurement may pass without demonstrating compliance with the JTRS architecture. We believe DOD will have difficulty in enforcing such a gatekeeper function. In previous reports we showed instances in which DOD was unable to override service-unique priorities to achieve interoperability and implement DOD architectures.<sup>17</sup> These cases demonstrate that the services traditionally control acquisition programs and buy to meet service, not joint, requirements.

DOD also has not prepared a comprehensive joint test and evaluation master plan to guide service-level testing and to ensure that joint interoperability testing is conducted. Joint Program Office officials said they plan to establish an Integrated Product Team for interoperability testing. The officials said testing has been discussed with the Joint Interoperability Test Center, the Joint Spectrum Center, various service officials, and the Office of the Defense Operational Test and Evaluation. One official said the Joint Program Office intends to have the team produce a test and evaluation master plan to guide overall testing.

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## Conclusions

The JTRS program was established as a joint program to achieve cost savings over existing radio systems, improve performance, and address well-known interoperability problems among service-unique radios. DOD issued instructions to the services to stop all current efforts to initiate any development and acquisition activity in service-unique radio and terminal programs. However, because JTRS products are not yet available, DOD issued waivers to the services, allowing them to continue procurement of other radios to meet near-term requirements. No date for fielding JTRS

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<sup>17</sup>Defense Management: Stronger Oversight of Joint Service Imagery Processing System Needed (GAO/NSIAD-91-164, July 1991); Defense Information Superiority: Progress Made, but Significant Challenges Remain (GAO/NSIAD/AIMD-98-257, Aug. 1998); and U.S. Atlantic Command: Challenging Role in the Evolution of Joint Military Capabilities (GAO/NSIAD-99-39, Feb. 1999).

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products has been established. Thus, DOD will most likely continue to receive waiver requests from the services to meet near-term requirements while the JTRS Joint Program Office prepares a JTRS architecture and a detailed acquisition strategy. The Joint Program Office expects the architecture and acquisition strategy to be available for review and approval at a major program decision meeting in October 2000.

On the basis of the progress made by the JTRS program and of the challenges ahead, we are concerned that DOD is currently not well positioned to achieve its expectation that the private sector will be able to meet key JTRS requirements. However, we believe DOD can enhance its position. First, if military requirements cannot be fully satisfied by developments in the commercial marketplace, a detailed technology plan would help to better leverage commercial technology development and ongoing DOD research programs associated with programmable radios and integrate these technologies into the JTRS program. Such a plan could (1) identify specific technologies that could be extracted from various commercial and DOD sources for potential use in the JTRS program and (2) select technologies for focused development and integration in the JTRS program. DOD could also use the technology plan as part of the process to ensure that the requisite technology will be mature as the program develops. Such a plan could also set standards for assessing the maturity of key technologies. Second, current significant risk in DOD's JTRS architecture development and its still-developing acquisition strategy could be reduced by incorporating alternatives, should a single architecture prove to be premature or not technically possible. Third, establishing interoperability as the top program priority would set the stage for program success. Identifying a minimum set of interoperability requirements is paramount for an undertaking as complex and extensive as JTRS. By knowing minimum interoperability requirements, DOD could determine what technologies need to be developed.

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## Recommendations

We recommend that the Secretary of Defense

- develop a JTRS technology plan for approval at the October 2000 major decision point that (a) addresses the specific limitations of commercial and DOD technology in satisfying current and future JTRS requirements, (b) establishes standards for assessing the maturity of JTRS technology, and (c) coordinates relevant DOD research and development programs to focus on JTRS;

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- establish specific milestones for assessing the commercial and technical feasibility of the single architecture approach and develop alternative architectures if indicated by the results of these assessments; and
  - identify, as a priority initiative, the precise requirements for interoperability among tactical radio communications systems.

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## Agency Comments and Our Response

In a general comment on a draft of this report, DOD indicated that it is fully supportive of JTRS and its projected capabilities, but did not agree with our recommendations. DOD stated that the draft showed a misunderstanding of the intent of the program in general and of the specific conduct and direction of the program. We disagree. Our report recognizes that the intent of the JTRS program is to consolidate various service-unique radio acquisition programs into a single, joint program with the objectives of lowering costs, improving performance, and improving interoperability in joint and coalition operations. We fully understand that DOD's conduct and direction of the JTRS program is based on the fundamental concept that industry, not DOD, is developing the JTRS open systems architecture and that this architecture is expected to result in a commercial market from which the services can procure JTRS products. As our report points out, our key concern is how DOD should position itself to counter the significant risk of implementing this single architecture concept. In our opinion, DOD must successfully address the challenges we identified or run the risk of reaching the October 2000 major decision point without (1) clearly identified technology deficiencies and a funded DOD-approved plan to address these deficiencies, (2) an adequate architecture to guide JTRS development, and (3) fully defined interoperability requirements. Deficiencies such as these could result in wasted funds, loss of time in program development, and renewed service pressure to return to service-specific programs.

DOD also made three specific observations concerning our recommendations. In our opinion, DOD's comments regarding our three recommendations reflect greater similarity of viewpoints on the general direction in which JTRS is already moving than is indicated by the Department's characterization of our report. Regarding our first recommendation, DOD said that although the Joint Program Office is developing a Technology Master Plan, its purpose is different than what is stated in our recommendation. However, DOD also states the Technology Master Plan will ensure that technology assessment is accomplished and that appropriate technologies are incorporated. The development of this plan—if not already consistent with the elements listed in our

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recommendation—could be made compatible with some modification. We also changed the language of the recommendation to emphasize that the Technology Master Plan should be prepared for approval at the October 2000 major decision point and address specific limitations of DOD and of commercial technology in meeting current and future JTRS requirements.

In disagreeing with our recommendation to prepare alternatives, DOD commented that it is aware of the risks inherent in adopting a single architecture for JTRS and that it may or may not be consistent with similar commercial standards. The Department stated that by taking this approach, the Joint Program Office is “corroborating that the single architecture accepted by DOD in the procurement process is also valid in the commercial market place.” In this regard, DOD stated that the fundamental concept is that industry, not DOD, is developing the accepted open systems architecture.

We believe that DOD’s response must be viewed in the context of the significant risks it is assuming. DOD’s intent that industry develop an architecture that is valid in the market place must be contrasted with the risks stated in our report—namely, that achieving widespread consensus on wireless standards will be difficult, and technical difficulties will surface. DOD’s point about the Joint Program Office’s recognition of risks does not address our concern that appropriate technologies may not be available to support the intended architecture unless DOD fully implements our recommendation that it develop a JTRS technology plan. Our recommendation is aimed at preparing alternative courses of action to address risks as they are recognized at periodic milestones leading to the October 2000 major decision point. Additionally, our recommendation is intended to better position DOD with alternatives to fall back on, thus mitigating potential adverse effects that DOD would experience should the single architecture not come to fruition. We changed the wording of the recommendation to emphasize that DOD should reassess the single architecture it proposes. This change makes the recommendation consistent with our proposal that DOD establish specific milestones and provide alternative courses of action.

While DOD indicated that it partially concurred with our third recommendation regarding improved interoperability, the Department presented a discussion essentially indicating concurrence.

DOD’s comments are reprinted in their entirety in appendix II. In addition, DOD provided technical comments that we incorporated as appropriate.

## Scope and Methodology

To determine the status of the JTRS program and future DOD development plans for the program, we interviewed appropriate officials in the JTRS program office; the Office of the Assistant Secretary of Defense for C3I; and the Army, the Navy, and the Air Force. We reviewed documentation establishing the program and its objectives and requirements. We also reviewed correspondence, cost and schedule data, and other documents relating to the JTRS program.

To identify challenges DOD faces in implementing its JTRS acquisition strategy, we analyzed data from DOD and appropriate commercial sources. To obtain this data, we interviewed appropriate officials in the JTRS program office; the Office of the Assistant Secretary of Defense for C3I; and the Army, the Navy, and the Air Force. We also interviewed some of the authors and analyzed multiple reports prepared by non-DOD organizations for DOD, its agencies, and the services assessing commercial technology for military missions. We then assessed what these experts said about each key performance parameter, specifically whether the experts determined that the technology needed to fulfill the requirement was commercially available or whether further development was needed under DOD sponsorship. The scope and methodology of our analysis of the various studies is further discussed in the introduction to appendix I. We visited DOD and service research organizations and laboratories and interviewed appropriate officials to discuss and assess their research programs, availability of relevant commercial technology for DOD purposes, and inclusion of relevant DOD and commercial technology into the JTRS program. We also visited the Atlantic Command and the Central Command to discuss user requirements for JTRS.

We performed our work from August 1998 to August 1999 in accordance with generally accepted government auditing standards.

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We are sending copies of this report to Representative John Murtha, Ranking Minority Member, Subcommittee on Defense, Committee on Appropriations; Representative C.W. Bill Young, Chairman, and Representative David Obey, Ranking Minority Member, Committee on Appropriations; and other interested congressional committees. We are also sending copies to the Honorable William Cohen, Secretary of Defense; the Honorable Louis Caldera, Secretary of the Army; the Honorable Richard Danzig, Secretary of the Navy; and the Honorable F. Whitten

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Peters, Secretary of the Air Force. Copies will also be made available to others upon request.

If you have any questions regarding this report, please contact Charles F. Rey at (202) 512-4174 or Robert R. Hadley at (202) 512-4340. Key contributors to this assignment were Subrata Ghoshroy and Raffaele Roffo.

Sincerely yours,



Allen Li  
Associate Director  
Defense Acquisitions Issues



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## Abbreviations

AITG	Airborne Ingegrated Terminal Group
A&T	Acquisition and Technology
C3I	Command, Control, Communications, and Intelligence
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DMR	Digital Modular Radio
JTRS	Joint Tactical Radio System
NTDR	Near-Term Digital Radio
ORD	Operational Requirements Document



# Technology Challenges for JTRS

Table I.1 summarizes our analysis of several recent studies and reports published by recognized experts in the field of radio communications who individually concluded that the Joint Tactical Radio System (JTRS) faces a number of technological challenges. We reviewed these studies and reports to determine if a consensus existed among the various experts about these technological challenges. We also interviewed some of the authors to obtain a better understanding of the issues. The point of reference for our analysis was the JTRS Operational Requirements Document (ORD), which describes the performance requirements of the Joint Tactical Radio. These requirements are classified in the ORD as either threshold (minimum) or objective (desired by the user), and some threshold requirements are further defined as a key performance parameter. A key performance parameter is a capability or characteristic that is so significant that failure to meet it can cause the concept or system selection to be reevaluated or the program to be reassessed or even terminated. We identified those ORD requirements that were highlighted in these reports, in addition to those that are already designated as key performance parameters, and matched the specific technologies that are needed to satisfy them.

A brief description of each report follows. The National Research Council report titled "The Evolution of Untethered Communications," was the outcome of a yearlong study sponsored by the Defense Advanced Research Projects Agency (DARPA). The concept "untethered communications" includes both mobile and wireless operations. The primary focus of the study was to recommend to DARPA where to invest in information technology for mobile wireless systems. The RAND study was sponsored by the U.S. Army Training and Doctrine Command. RAND was tasked to recommend to the Army specific basic and applied research areas where progress was needed to address gaps between military requirements and presently available and emerging technologies. Overall findings of the study were published in a report titled "Fundamental Research Policy for the Digital Battlefield." A companion report called "Emerging Commercial Mobile Wireless Technology and Standards: Suitable for the Army?" documented the results in detail. The Programmable Modular Communications Systems Guidance Document published by the Department of Defense provides a Systems Reference Model and rules for its use by the communications systems designer. The document identifies numerous technology issues that industry and government must address, which are cited here as appropriate. Finally, we highlight the viewpoint of industry regarding the deficiencies of commercial technology. We used the results of a Request for Information issued by the JTRS Special Task Force, which sought the opinions of industry and academia on the planned JTRS

**Appendix I**  
**Technology Challenges for JTRS**

acquisition strategy. In the Joint Program Office's assessment, the respondents identified a number of technology hurdles and confirmed that JTRS requires significant military capabilities not applicable to the private sector.

**Table I.1: Comparison of Independent Technology Assessments**

JTR ORD requirements	Specific technology required to satisfy ORD	NRC report on wireless communications 1997	RAND report 1998	PMCS guidance document 1997	Industry viewpoint (JTRS JPO survey) 1998	Classification of the parameter in the ORD
2 MHz – 2 GHz multiband, multimode	Advanced antennas	X	X	--	X	Key performance parameter (KPP)
Software programmable	Filter technology, DSP	X	X	X	X	KPP
Multiple channels simultaneously	Co-site interference mitigation	X	--	X	X	KPP
Load new modes and reconfigure capabilities via software, while in operation	Software definition of waveforms (portability)	--	--	X	X	KPP
Internal growth capability through modular, scalable open systems architecture	Open systems architecture	X	--	X	X	KPP
Provide networking services for connected RF networks and between different networks	Network protocol, management, mobility	X	X	X	X	KPP
Secure communications	Programmable TRANSEC, COMSEC, INFOSEC	X	X	X	X	Threshold
Output power: milli-watts to tens of watts 2 MHz–2 GHz	Broadband amplifiers	X	X	X	X	Threshold
2 Mbps data rate	High-speed A/D converters	X	X	X	X	Threshold

(Notes on next page)

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#### Legend

X = Item is identified as a deficiency and requires further research and development  
-- = Item is either not emphasized or not discussed in the study  
A/D = analog to digital  
COMSEC = communications security  
DSP = digital signal processor  
GHz = gigahertz  
INFOSEC = information systems security  
JPO = Joint Program Office  
Mbps = megabits per second  
MHz = megahertz  
NRC = National Research Council  
ORD = Operational Requirements Document  
PMCS = Programmable Modular Communications System  
RF = radio frequency  
TRANSEC = transmission security



# Comments From the Department of Defense

Note: GAO's comments supplementing those in the report text appear at the end of this appendix.

See pp.16-18



OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE  
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August 10, 1999

COMMAND, CONTROL,  
COMMUNICATIONS, AND  
INTELLIGENCE

Mr. Allen Li  
Associate Director, Defense  
Acquisition Issues  
National Security and  
International Affairs Division  
U.S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Li:

This is the Department of Defense (DOD) response to the General Accounting Office (GAO) draft report, "DEFENSE ACQUISITIONS: CHALLENGES ASSOCIATED WITH IMPLEMENTING THE JOINT TACTICAL RADIO SYSTEM," dated July 6, 1999 (GAO Code 707370/OSD Case 1858).

The DOD has reviewed the findings of the GAO and believes that there are a number of areas of misunderstanding by the GAO of the intent of the program in general and the specific conduct and direction of the program. The DOD comments on the three GAO recommendations together with the proposed technical corrections are enclosed. This Office together with the Joint Program Office attempted to fully address details of the report which are considered inaccurate. We are prepared to discuss these specific discrepancies as may be desired.

The Department is fully supportive of the Joint Tactical Radio System and the projected capabilities it will provide to the warfighter while improving interoperability and offering cost savings. It should be noted that prior to initiating the JTRS program there were twelve various multi-band, multi-mode radio (MBMMR) programs in various stages of development within the Department.

The DOD appreciates the opportunity to comment on the GAO draft report.

Sincerely,

Arthur L. Money  
Senior Civilian Official

Enclosure



**GAO DRAFT REPORT DATED JULY 6, 1999  
(GAO CODE 707370) (OSD CASE 1858)**

**"DEFENSE ACQUISITIONS: CHALLENGES ASSOCIATED WITH IMPLEMENTING  
THE JOINT TACTICAL RADIO SYSTEM"**

**DEPARTMENT OF DEFENSE COMMENTS TO  
THE GAO RECOMMENDATIONS**

**RECOMMENDATION 1:** Develop a JTRS technology plan that (a) includes the specific limitations of commercial and DOD technology in satisfying current and future JTRS requirements, (b) establishes standards for assessing the maturity of JTRS technology, and (c) coordinates relevant DOD research and development programs to focus on JTRS.

See comment 1.

**DOD RESPONSE:** Non-Concur. Although the JTRS JPO is developing a Technology Master Plan its purpose is different than those stated in the GAO recommendation. The JPO Technical Master Plan will ensure that technology assessment is accomplished and appropriate technologies are incorporated. The Technology Master plan will aid in identifying technologies, which are sufficiently mature for incorporation into JTRS products, as well as focusing technology development. The GAO recommendation is inconsistent with the precepts of the JTRS program. The original JTRS philosophy as depicted in the Operational Requirements Document and in the development process as executed by the JPO is for industry to provide the best possible solutions for the JTRS family of radios via an open systems architecture. This open systems architecture is responsive by nature to changes in technology and is flexible in design to accommodate technological advances in software and hardware. This underlying philosophy is part in parcel to the JTRS development and the inclusion of appropriate technologies by industry is a hallmark of the JTRS program. The JTRS JPO currently has a close working relationship with the Defense Advanced Research Programs Agency (DARPA) and is incorporating technology issues into the development process for the JTRS.

See comment 2.

**RECOMMENDATION 2:** Prepare an alternative for architecture development by (a) establishing specific milestones for assessing commercial standards and architectures and (b) providing alternative courses of action as indicated by the results of these assessments.

See comment 3.

**DOD RESPONSE:** Non-Concur. We recognize the risks inherent in adopting a single architecture for the JTRS that may or may not be consistent with similar commercial standards and also recognizes the import of alternatives should the architecture deviate from industry norms. The requirement for industrial participants to provide the full technical architecture along with a management plan that would ensure that the architecture is (1) accepted by industry at large, and (2) proven to be an open system industrial standard, which was inherent in the JPO Step 1 and Step 2 solicitations, evaluations, and selection processes. By taking this approach to the acquisition process, the JPO is corroborating that the single architecture accepted by DOD in the procurement process is also valid in the commercial market place. It is also important to note that the JTRS JPO has consistently taken a view that proposals must include a plan for ensuring that the architecture is open for all industry and is accepted by industry at large as the open standard for a software defined radio. The fundamental concept is that industry, not DOD, is developing the accepted open systems architecture. In fact, all three consortia participating in the recently completed Step 1 process are committed to having the architecture accepted by the

See comment 4.

See comment 5.

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**Appendix II**  
**Comments From the Department of Defense**

See comment 6.

Software Defined Radio Forum, a formal industrial affiliation sponsoring the definition of software radio standards for industry and other standards bodies.

**RECOMMENDATION 3:** Identify, as a priority initiative, the precise requirements for interoperability among tactical radio communications systems.

**DOD RESPONSE:** Partially Concur. The fundamental precept of the JTRS is to ensure interoperability. The DOD fully appreciates the requirement for the JTRS to be interoperable within the joint environment and fully supports the need for interoperability. As part of the responsibility for maintaining the Joint Operational Requirements Document, the Army, through the Training and Doctrine Command (TRADOC), continues to review the JTRS requirements. In response to a tasking from the Joint Staff, the Army is currently reviewing the interoperability requirements including waveform requirements and cross banding requirements among the Services and the operational CINC's. In addition, the JTRS JPO intends to initiate a formal Requirements Integrated Product Team under standard Army procedures for the purpose of reviewing operational requirements and ensuring interoperability. The Army, as the lead Service for the Joint Radio System Program, is committed to ensuring joint interoperability consistent with the requirement documents for the JTRS.

The following are GAO's comments on the Department of Defense's (DOD) letter dated August 10, 1999.

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## GAO Comments

1. Our recommendation is based on the recognition that there are limitations to the technology that can be provided by commercial developers and that these limitations need to be factored into an acquisition strategy. We believe that industry at large may not be capable of supporting all of the key JTRS performance requirements and that some unique technologies may not be available to satisfy all the requirements of the JTRS. DOD should have a plan to deal with that possibility. Therefore, we see no inconsistency between our recommendation and the intention and/or principles of the JTRS program. Furthermore, although DOD disagrees with our recommendation, it also comments that the Joint Program Office is in the process of developing a technology plan. According to DOD, this Technology Master Plan is expected to ensure that technology assessment is accomplished and that appropriate technologies are incorporated. By adopting such a plan, DOD would meet the intent of our recommendation, and if this plan is not already consistent with our recommendation, it could be made compatible with some modification.
2. Although DOD states that its philosophy is for industry to provide the best possible solutions for the JTRS family of radios via an open systems architecture, DOD officials have acknowledged that DOD does not have adequate information today to make an evaluation of industry potential. As noted in our report, the Joint Program Office will conduct a market survey to determine industry's readiness to produce JTRS compliant systems. In addition, our report identifies limitations of current and future commercial technology to meet key military performance requirements identified in several reports published by recognized experts in the field of radio communications. Our report also notes that DOD has research underway to provide necessary JTRS technology but that departmental and service research programs are not adequately coordinated with JTRS development plans.
3. During our review, Joint Program Office officials told us they have only individual staff level contacts with DARPA but intend to approach DARPA officials to establish a more formal working relationship.
4. Although DOD indicates nonconcurrence, its comments show recognition of the significant risks inherent in adopting a single architecture for the JTRS that may or may not be consistent with similar

commercial standards. DOD's comments also recognize that the JTRS architecture developed by the industrial consortia may not be consistent with industry norms. Our recommendation focuses on the development of a plan that includes such recognition.

5. DOD's fundamental philosophy is that industry, not DOD, is developing the open systems architecture needed for JTRS. DOD states this philosophy is inherent in the Joint Program Office's contract solicitations, evaluations, and selection process. DOD hopes this open systems architecture will be widely accepted by industry. However, DOD has no assurance that its expectations for the JTRS architecture to receive widespread industry acceptance will be achieved. DOD is requiring industrial participants in the JTRS architectural development effort to provide a plan that would ensure that the architecture is accepted by industry at large. According to DOD, these firms are committed to having the architecture accepted by the Software Defined Radio Forum, a formal industrial affiliation sponsoring the definition of software radio standards for industry and other standards bodies.

However, our report pointed out the National Research Council discussion of difficulties in achieving widespread consensus on standards in wireless communications. Thus, the single consortia selected by the Joint Program Office to develop the architecture cannot be assumed to represent an industry-wide perspective, and the Software Defined Radio Forum may or may not accept the JTRS architecture and sponsor it to industry and other standards bodies.

6. Although DOD only partially concurred with our third recommendation, actions such as the Army's review of interoperability requirements and the establishment of a formal Integrated Product Team to review operational requirements are consistent with our recommendation.

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